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Zenatiopsis ultima sp. nov., Terminal Species of the *Zenatiopsis* Lineage (Bivalvia: Mactridae)

With notes on its stratigraphic significance on Flinders Island and in the Perth Basin, Southern Australia

By T. A. Darragh† and G. W. Kendrick*

Abstract: The terminal species of the *Zenatiopsis* lineage (*Zultima* sp. nov. Upper Pliocene (?)—Lower Pleistocene (?)) is described and a brief account given of the stratigraphic background to its occurrence on Flinders Is. and in the Perth basin.

INTRODUCTION

Since the publication of Gill and Darragh (1963) on the subfamily Zenatiinae, further information and material of the extinct genus *Zenatiopsis* has come to hand. In particular, additional material concerning the end member of the *Zenatiopsis* lineage now enables this species to be formally described.

STRATIGRAPHIC OCCURRENCES

The precise ages and correlation of some of the formations containing *Zenatiopsis ultima* sp. nov., are still not clearly established, and it is hoped that this account of the species may contribute to the stratigraphical correlation of late Cainozoic marine deposits in southern Australia.

The stratigraphy and problems of the Dry Creek Sands have been discussed by Ludbrook (1954, 1963) and of the Glenelg Region by Singleton (1941) and to some extent by Boutakoff (1963). However the late Cainozoic stratigraphy of Flinders Island and the Perth Basin is yet to be studied in detail, and there is little in the literature about it. The following notes have therefore been compiled as a contribution towards a stratigraphic perspective for *Zenatiopsis ultima* sp. nov.

New work reported below from Flinders Island has been done by T. A. Darragh: that from the Perth Basin by G. W. Kendrick.

Flinders Island

The late Cainozoic sediments of the eastern coastal plain of Flinders Island do not outcrop, but have been exposed in the many dams and drains excavated by the Agricultural Bank of Tasmania during the development of the Furneaux Estate. The only published account of these sediments is a brief statement by Wilkins (1962) who described two Pliocene formations: the Cameron Inlet Marl and the Dutchman Coquinoid Limestone. The latter is of small areal extent, and the former changes rapidly from limestone through marl to sands and gravels. Hence one name, the Cameron Inlet Formation is applied herein to both these related Pliocene units.

The general distribution of the late Cainozoic marine deposits on Flinders Island has been studied by Darragh in the course of a recent visit. Though much detailed work remains outstanding, there appear to be three recognizable formations, two of which are widely distributed. The oldest of these, the Cameron Inlet Formation, consists predominantly of sands, gravels, coquina and marl, and is distributed from the foot of The Dutchman in the south to at least as far north as Wingaroo. The best sections are visible in the bottom of the Nelson Lagoon drain and the sides of the North Patriarch drain. The thickness is not known, though some dams excavated in the Formation are up to 13 ft deep, of which 3-4 ft at the top would represent surface soil and sand. At Wingaroo, bores up to 80 ft deep were still in what appears to have been Cameron Inlet Formation (Singleton and Woods, 1934).

The age of the Cameron Inlet Formation is

† National Museum of Victoria, Russell Street, Melbourne, Victoria 3000.
* Western Australian Museum, Beaufort Street, Perth, W.A. 6000.

considered to be post-Kalimnan, from the presence in it of many extant mollusc species such as *Umbilia hesitata* Iredale, *Cassis* (*Hypocassis*) *fimbriata* (Quoy and Gaimard), *Ericusa papillosa* (Swainson), and *Neotrigonia* cf. *margaritacea* (Lamarck). Also present are many 'Kalimnan' species such as *Glycymeris convexa* (Tate), *Tylospira coronata* (Tate), and *Cucullaea praelonga* Singleton, as well as certain indigenous species including *Singletonaria gilli* Marwick and *Miltha flindersiana* Singleton and Woods. From this assemblage it is concluded that the age of the Cameron Inlet Formation is Middle to Upper Pliocene.

The Cameron Inlet Formation is disconformably overlain by a younger, widespread and unnamed formation of rather similar lithology. This is however less rich in carbonate, and consequently contains no marls. This formation occurs on the north eastern coastal plain from No. 2 Road to at least as far N. as Wingaroo.

The contact between the unnamed formation and the underlying Cameron Inlet Formation has not been seen, but in dams excavated in the younger formation to the S. of No. 11 Road, worn remanié fossils derived from the Cameron Inlet Formation have been found. A little way further S., the younger formation gives way to the Cameron Inlet Formation.

The thickness of the unnamed younger formation is not known but, from the evidence of dams excavated in it, it is at least 10 ft. The mollusc fauna is essentially modern, except that the genus *Zenatiopsis* is present. Hence it is concluded that the formation is of Werrikooian age

Specimens of *Zenatiopsis ultima* sp. nov. occur rarely and were found only in the spoil heaps of dams excavated in the very fine sands of this younger formation.

In the vicinity of Burnett Lagoon and Cameron Inlet, the Cameron Inlet Formation is overlain by a thin veneer of shell beds which we consider to be probably of late Holocene age. These are well exposed in the sides of the Nelson Lagoon drain, where they are about 1 ft thick.

Perth Basin

Drilling for water on the coastal plain near Perth has revealed the presence of previously unrecorded late Cainozoic marine deposits at shallow depths between the surface sands and clays and the underying Cretaceous Osborne Formation.

No surface outcrops of these (post-Cretaceous) beds are known. All fossiliferous samples acquired by the Western Australian Museum were initially recovered as sludge samples from water boring operations. The deposits contain rich molluscan assemblages which appear to represent not less than two distinct faunas.

An older fauna is recognizable in bores from the eastern side of the Perth Basin, both N. and S. of Perth, and notably in the Bullsbrook, Redcliffe and Gosnells districts. The characteristic lithology is that of a grey, strongly lithified, medium to very coarse grained calcarenite, with embedded mollusc shells and numerous small fragments of charcoal.

The samples available for study are at present small and many of the specimens recovered have sustained damage from the drill and sludge pump. Comprenhensive study of the fossils from Bullsbrook-Redcliffe-Gosnells group of bores has yet to be undertaken. Specimens of the extinct, pelagic genus *Hartungia* (Gastropoda: Janthinidae) have been found in several bore samples, but no specimen of *Zenatiopsis* has yet been recovered. A provisional age of Pliocene (?) to early Pleistocene is suggested for these assemblages.

A younger fauna, which appears to be of Pleistocene age, is present in deposits underlying more central parts of the Perth Basin, particularly S. of Perth in the Jandakot and West Coolup districts, where the beds constitute a significant shallow aquifer. Specimens of *Zenatiopsis ultima* have been recovered from water bores at Jandakot, situated 11 miles S. of Perth City. Two of these bores are:

(i) *Paulik's bore*, situated at the eastern end of Lot 41, Semple Rd, Jandakot: surface elevation 73 ± 5 ft above State Mean Sea Level: depth of bore 140 ft. *Z. ultima* has been collected from 122½-136 ft below the surface.

(ii) *Adrian's Nursery bore*, situated on Lot 18, near the corner of Thomas and Semple Rds, Jandakot: surface elevation 75 ± 5 ft above State Mean Sea Level: depth of bore 130 ft. *Z. ultima* has been collected from 126-129 ft below the surface.
Adrian's Nursery bore is located approximately one quarter mile south from Paulik's bore.

The characteristic lithology of the marine deposits at Jandakot (and at West Coolup) is that of a grey, fine to coarse grained, unconsolidated quartz sand, which frequently contains a high proportion of well preserved shells.

The most complete and informative sequence, obtained from Paulik's bore, consists, from the surface down, of 71 ft of non-fossiliferous sand overlying 69 ft of richly fossiliferous shell sand,

with minor intercalations of silt, algal and other limestone, pebble concentrations and, in the upper levels, much carbonaceous material. Unconformable contact with Cretaceous sediments was established in this bore at a depth of 140 ft, where drilling ceased.

The fossiliferous sequence in Paulik's bore, lying between 71 and 140 ft below the surface, is considered probably to include both transgressive and regressive deposits of the shallow neritic and littoral environments. However, satisfactory correlation of several suspected disconformities with other bores in the district has yet to be demonstrated.

The *Zenatiopsis*-bearing shell sands in Paulik's bore lie between 49½ and 67 ft below State Mean Sea Level. Near the middle of this sequence at 58½-59 ft below datum, is a pale brown friable fine-grained limestone containing shells of the non-marine aquatic snail *Physastra* (Gastropoda: Planorbidae). No marine fossils have been observed in the *Physastra* bearing matrix which is interpreted to indicate an interval of lacustrine deposition, consequent upon a brief seaward displacement of the strand line.

It is believed (Fairbridge and Teichert 1953) that the Perth Basin has been tectonically stable during Quaternary times. Lowry (1965) describes evidence of such stability from early Quaternary sediments in the southern part of the basin. It is assumed from this that the Quaternary deposits at Jandakot have also been stable since deposition, and that the sea stood at approximately 60 ft below modern level for a brief interval during the time represented by the *Zenatiopsis* bearing strata in Paulik's bore.

The main zoogeographical features of the living shallow marine fauna of Western Australia have been described by Ride and Serventy (1965). They refer to two principal elements—a northern tropical and a southern temperate fauna, which meet in "a broad area of overlap between North West Cape and Cape Leeuwin" (ibid, p. 70).

From a preliminary study of 98 molluscan species associated with *Z. ultima* from 126-129 ft in Adrian's Nursery Bore, Jandakot, it is estimated that not less than 72% of the species present are identical with or very close to extant southern Australian forms, including 17% considered to be now living E. but not N. from Cape Leeuwin. Examples of this latter group are *Glycymeris* (*Tucetilla*) *mayi* Cotton, *Limopsis tenisoni* Tenison Woods, *Chlamys* (*Equichlamys*) cf. *bifrons* (Lamarck), and *Placamen placidum* (Philippi).

Molluse species of Indo-Pacific affinity estimated by Kendriek to constitute about 20% of the living fauna at the latitude of Fremantle, amount to less than 5% of the species associated with *Z. ultima* in Adrian's Nursery Bore, Jandakot.

Compared with the living molluscan fauna from comparable environments near Fremantle, the Jandakot assemblage which includes *Z. ultima* appears to have stronger affinities with southern and south eastern Australia, and weaker affinities with north western Australia. We conclude from this that sea temperatures may have been cooler than at present during the time represented by the *Zenatiopsis* bearing sequence at Jandakot. This conclusion, combined with evidence for a sea level approaching 60 ft below modern level for part of that time, suggests that this sequence was formed during a glacio-eustatic regression of the sea, at some undetermined stage of the Pleistocene.

Of the samples so far studied, about 10-15% of molluses associated with *Z. ultima* at Jandakot may represent extinct species. These include *Nuculona* (*Ennucula*) *kalimnae* (Singleton), *Semivertagus capillatus* Tate, *Austromitra* cf. *multiplicata* Ludbrook, *Marginella* (*Austroginella*) *johnstoni* Petterd and species (possibly undescribed) of *Limatula, Cuna, Tawera, Deltachion, Leiopyrga* and *Bellastraea. Semivertagus capillatus* occurs with *Z. ultima* below the *Physastra* bed in Paulik's bore, but has not been observed above this horizon. No extinct genus other than *Zenatiopsis* is at present recognized in the Jandakot-West Coolup assemblages.

Examination of a considerable quantity of fossil material from water bores at Jandakot and West Coolup has failed to reveal any trace of shells of the genus *Pecten*. It appears probable that the fauna associated with *Z. ultima* predates the arrival of *Pecten* in south western Australia, an event which Fleming (1957) suggests occurred during the Pleistocene.

SYSTEMATIC DESCRIPTION

Zenatiopsis ultima sp. nov.

(Pl. 1, fig. 1, 4-6.)

Zenatiopsis angustata. Ludbrook 1955. *Trans roy. Soc. S. Aust. 78*: 77.

Zenatiopsis sp. nov. Gill & Darragh 1963. *Proc. Roy. Soc. Vict. 77*(1): 185.

DIAGNOSIS: A *Zenatiopsis* with a prominent lunule and with the left bifid cardinal directed only slightly posteriorly, normal to the hinge line, or slightly anteriorly.

DESCRIPTION: Shell large and solid for the genus, elongate oval, gaping at both ends, posterior gape longer; exterior concentrically striated with growth lines. Umbones small, pointed, orthogyral, situated ⅛ the length of the shell from the anterior end.

Lunule considerably encroaching on the interior of both valves. Tooth formula (Gill & Darragh, 1963)

$$\frac{3a \quad 3b}{LAI1 \quad 2a, 2b \quad 4b}$$

Bifid cardinal 2a, 2b narrow, vertex directed slightly posteriorly, normal to the hingeline or slightly anteriorly. Internal ridge prominent, thick, flattened, extending from under the hinge plate between 2a and 2b. Pallial sinus extending to the middle of the valve. Muscle scars subequal, the posterior larger, subtriangular and elongated laterally, the anterior subcircular slightly elongated dorso-ventrally.

Dimensions: (millimetres)	Length	Height	Thickness (both valves)	Umbo to anterior end
Holotype NMV P26894	103	39	16	17 (Pair)
Paratype NMV P26895	85	33	14	14 (Pair)
Paratype WAM 68·1259a, b	100	38	15	15 (Pair)
WAM 68·1259c, d	87	30	11	13 (Pair)

Location of Types: National Museum of Victoria. Holotype P26894, Paratype P26895, collected T. A. Darragh, D. M. Shanks and H. E. Wilkinson, 5.2.1969. Western Australian Museum. Paratype 68.1259a, b, collected D. G. F. Smith, 1968.

Type Locality: Dam in shelter belt, SW. side of No. 2A Road, 1·1 miles NW. of junction with No. 2 Road, Grid Reference—Flinders Island 931 762, Flinders Island, Tasmania.

Stratigraphical Range: Upper Pliocene (?) to Lower Pleistocene (?).

Occurrence:

1. *Flinders Island, Tasmania.*
Unnamed formation. Werrikooian—Plio-Pleistocene.
   (a) Type locality, 6 specimens. NMV P26894-6.
   (b) Cook's dam, Block 77, Furneaux Estate, Section D, WAM 68·1259.
   (c) Dam on Block 82, Furneaux Estate, Section D, 1·4 miles NE. of No. 2 Road, 0·2 miles NW. of No. 11 Road East, Grid Reference—Flinders Island 940 792, NMV P26898.
2. *Victoria.*
Werrikoo Member, Whaler's Bluff Formation. Werrikooian-Plio-Pleistocene?
   (a) Limestone Creek, Glenelg River, NMV P21840-1, P21957.
   (b) Shell bed just above water level, Minnie Creek, Allotment 27, Parish of Myaring. Grid reference—Dartmoor (approx.) 240 404, NMV P26900.
3. *South Australia.*
Dry Creek Sands, Upper horizon. Upper Pliocene. Abattoirs Bore, Adelaide. NMV P26899.
4. *Western Australia.*
Unnamed formation. Pleistocene.
   (a) Paulik's bore, E. end of lot 41, Semple Road, Jandakot. Grid Reference—1:250,000 series, sheet S1 50-2 Pinjarra 384029.
   122½—123 ft below the surface, WAM 68-1448-50
   133 ft below the surface, WAM 68-1446
   136 ft below the surface, WAM 68-1443-4
   (b) Adrian's Nursery bore, lot 18, near corner of Thomas and Semple Roads, Jandakot. Grid reference Pinjarra 383028.
   126-129 ft below the surface, WAM 67-600
   (c) Jandakot Cement Works bore, lot 4, Parkes Road, Jandakot. Grid Reference Pinjarra 382029.

Comparison With Other Species: Gill and Darragh (1963) have already summarized the distinctive characteristics of this and the other species of *Zenatiopsis*: of *Z. ultima* the most important and obvious characteristic is the prominent lunule, a feature either poorly developed or generally lacking in other members of the genus. Comparison with the Upper Oligocene *Z. fragilis* Pritchard shows that the Oligocene species has its left cardinal teeth directed well to the anterior and the dorsal and ventral margins are generally curved more prominently than *Z. ultima*. The Miocene *Z. angustata* Tate has a similar tooth orientation but is a smaller and more fragile shell with a narrow, acute and curved internal ridge quite unlike that of *Z. ultima* and has no obvious lunule. *Z. phorea* Gill and Darragh (highest Upper Miocene-Lower Pliocene) has prominently posteriorly directed cardinals and either a small lunule, or none. It is probable that these species form a simple lineage whose origin is not known but was most probably derived in the Eocene from the ancestors of the earliest known New Zealand *Zenatia* (Oligocene).

Comments: No other species of *Zenatiopsis* is known to have had as widespread a distribution as *Z. ultima*, which we have recorded across southern Australia from localities near Perth in the W. to Flinders Island in the E. However, it is possible that the apparently restricted ranges of the preceding species may be due to the superior records of Tertiary deposition preserved in south-eastern Australia, compared with regions further to the W.

Though no geological formation is known which contains more than a single species of *Zenatiopsis*, we can find no clear evidence which would satisfactorily account for the extinction of the genus in early Pleistocene times.

The closely related genus *Zenatina*, which was sympatric with *Zenatiopsis* in the Victorian Lower Pliocene, is still living on the eastern coast of Australia. Pleistocene generic extinction among marine molluscs is exceptional in southern Australia. In fact most of the genera of molluscs present in the Lower

Pliocene (Kalimnan) of Victoria are still represented by living species on the Victorian and New South Wales coasts.

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DESCRIPTION OF PLATE 1

All photographs by F. Guy of the Royal Melbourne Institute of Technology.

Fig. 1—*Zenatiopsis ultima* sp. nov., P26894, holotype, left valve, Flinders Is., × 1.

Fig. 2—*Zenatiopsis angustata* (Tate), P22527, hypotype, left valve hinge region, Murray River cliffs, four miles S. of Morgan, S.A., × 4.

Fig. 3—*Zenatiopsis phorca*, Gill & Darragh, P21922, paratype, left valve hinge region, McDonald's Bank, Muddy Creek, Vic. × 3.

Fig. 4—*Zenatiopsis ultima* sp. nov., P26894, holotype, left valve hinge region, × 2.

Fig. 5—Ditto, P26894, holotype, right valve, × 1.

Fig. 6—Ditto, P26894, holotype, left valve, × 1.